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TITLE: Hot plate and method of manufacturing semiconductor device

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Abstract Text - ABTX (1):

In chucking a wafer to an electrostatic chuck type hot plate mounted in a semiconductor manufacturing apparatus, the chucking force is successively applied from the central portion toward the outer peripheral portion of the wafer. Therefore, the chuck electrode is divided in its radial direction into at least two electrode portions comprising an inner circumferential electrode portion and an outer circumferential electrode portion, and the chuck voltage is applied successively from the inner circumferential electrode portion toward the outer circumferential electrode portion. The chucking force is applied first to the central portion of the wafer so as to elevate the wafer temperature. In this step, the chucking force in the outer peripheral portion of the wafer is weak so as to permit the wafer to be thermally expanded smoothly. As a result, the stress within the wafer is low so as to prevent the wafer from being broken.

Brief Summary Text - BSTX (7):

In manufacturing a semiconductor device, a semiconductor circuit is formed by repeating the steps of forming an insulating film and a conductive film on a semiconductor substrate or wafer (hereinafter "wafer") such as a silicon substrate by a sputtering method, a CVD (Chemical Vapor Deposition) method, etc., and etching these films for the patterning purpose. Chemical reactions are utilized for the deposition and etching of the film, and the deposition rate and the etching rate are affected by the temperature. The quality of the deposited film is also affected by the temperature. It follows that it is important to control appropriately the temperature of the wafer under processing in order to carry out the processing stably with good reproducibility.

Brief Summary Text - BSTX (11):

However, in the case of allowing the wafer of room temperature to be

electrostatically held on the conventional electrostatic chuck type hot plate having a high temperature, serious problems are generated. For example, the wafer tends to be cracked. Also, it is difficult to dispose accurately the wafer on the hot plate.

Brief Summary Text - BSTX (13):

Where the wafer 103 of room temperature is disposed and chucked on the hot plate having a high temperature, the wafer 103 is thermally expanded in accordance with the temperature elevation. However, since the wafer 103 is fixed to the entire surface of the plate body 100 by the electrostatic chucking force, the wafer 103 fails to be expanded sufficiently as shown in FIG. 17, with the result that the wafer 103 is finally cracked by the compression stress. Particularly, if the hot plate has a high temperature, the wafer 103 is much expanded thermally so as to promote the cracking of the wafer 103.

Brief Summary Text - BSTX (14):

As described above, the wafer 103 is cracked by the compression stress in the case where the wafer 103 of room temperature is chucked on the conventional electrostatic chuck plate having a high temperature. Also, dust is generated by the rubbing, and the transfer error is generated by the deviation of the wafer 103. What should also be noted is that the electrostatic chucking force is changed depending on the kind of the film formed on the back surface of the wafer, with the result that the frequency of the crack occurrence differs depending on the kind of the film formed on the back surface of the wafer 103.

Brief Summary Text - BSTX (15):

Further, the degree of discharge in the chuck releasing step also differs depending on the kind of the film formed on the wafer. Therefore, the wafer releasing process continues to operate even if the chucking force is not eliminated completely, thereby bringing about a transfer deviation (jumping) as shown in FIG. 18. In order to overcome the difficulty, the wafer is held on the hot plate before application of the chuck voltage and, after heated to some extent to permit the thermal expansion, the wafer is chucked on the hot plate. Alternatively, the chuck-releasing time is set long. However, these methods give rise to the problem that the through-put is markedly lowered. Also, where it is necessary to start the film formation during the temperature elevation of the wafer as in the Al reflow process, the Al filling properties are deteriorated so as to lower the yield.

Brief Summary Text - BSTX (19):

According to a third aspect of the present invention, there is further provided a method of manufacturing a semiconductor device, comprising:

disposing a semiconductor substrate on a hot plate including a plate body, a heat generating electrode formed in the plate body and configured to heat the semiconductor substrate disposed on the hot plate, and an electrostatic chuck electrode formed in the plate body and divided into a plurality of electrode portions over the range from one outer peripheral portion to the opposite outer peripheral portion of the plate body via the central portion to include an inner circumferential electrode portion and an outer circumferential electrode; holding the semiconductor substrate on the hot plate by a chucking force generated by applying a chuck voltage to the electrostatic chuck electrode successively from the inner circumferential electrode portion toward the outer circumferential electrode portion to generate the chucking force successively from the inner circumferential electrode portion toward the outer circumferential electrode portion **temperature; and processing the semiconductor substrate** heated on the hot plate.

Drawing Description Text - DRTX (6):

FIG. 2B is a graph showing the change with time in the **wafer temperature** according to the first embodiment of the present invention;

Drawing Description Text - DRTX (9):

FIG. 4B is a graph showing the change with time in the **wafer temperature** according to the first embodiment of the present invention;

Detailed Description Text - DETX (3):

FIGS. 1 to 4 collectively show a first embodiment of the present invention. Specifically, FIG. 1A is a cross sectional view showing an electrostatic chuck type hot plate having a wafer mounted thereon, and FIG. 1B is a plan view schematically showing an electrostatic chuck electrode formed in the hot plate shown in FIG. 1A. Each of FIGS. 2A and 4A is a graph showing the change with time in the chuck voltage applied to the chuck electrode between the time when a chuck voltage is applied to the chuck electrode and the time when the wafer is chucked according to the first embodiment of the present invention. Each of FIGS. 2A and 4A also shows the chuck voltage after the wafer has been chucked. Each of FIGS. 2B and 4B is a graph showing the change with time in the **wafer temperature until the wafer** is chucked according to the first embodiment of the present invention. Each of FIGS. 2B and 4B also shows the **wafer temperature after the wafer** has been chucked. FIG. 3 is a graph showing the change with time in the chuck voltage between the time when the chuck voltage is applied to the chuck electrode and the time when the wafer is chucked according to the first embodiment of the present invention. FIG. 3 also shows the chuck voltage after the wafer has been chucked.

Detailed Description Text - DETX (7):

Then, predetermined positive and negative voltages are applied to the outer circumferential electrode 51 and the outer circumferential electrode 52 at time t_2 , which is time t later. In this step, the outer circumferential section of the wafer 3 is also chucked such that the entire region of the wafer 3 is chucked to the hot plate, with the result that the wafer temperature is rendered uniformly equal to temperature T of the hot plate. FIG. 2A is a graph showing the change with time in the chuck voltage, with FIG. 2B showing the change with time in the wafer temperature. The chuck voltage ($\pm V$) is plotted on the ordinate of the graph of FIG. 2A, with the time (seconds) for applying the chuck voltage being plotted on the abscissa. Further, the wafer temperature (degree C.) is plotted on the ordinate of the graph shown in FIG. 2B, with the time (seconds) for applying voltage to the chuck being plotted on the abscissa.

Detailed Description Text - DETX (8):

In this embodiment, voltage V is applied to the inner circumferential electrode portions at time t_1 and voltage V is applied to the outer circumferential electrode portions at time t_2 . Alternatively, it is also possible to apply the voltage $V_{sup.+}$ or $V_{sup.-}$ to the outer circumferential electrode portions at time t_2 , which is higher or lower than the voltage V applied to the inner circumferential electrode portions at time t_1 . It is possible to gradually increase the chuck voltage to a predetermined voltage. FIG. 3 is a graph showing the change with time in the chuck voltage. The chuck voltage ($\pm V$) is plotted on the ordinate of the graph, with the time (seconds) for applying voltage to the chuck being plotted on the abscissa. FIG. 3 shows that the voltage applied to the inner circumferential electrode portions at time t_1 is gradually increased to a predetermined voltage V . On the other hand, the predetermined voltage V is instantly applied at time t_2 to the outer circumferential electrode portions. However, it is also possible to increase gradually the voltage applied to the outer circumferential electrode portions. If the voltage applied to the electrodes is gradually increased, it is possible to decrease the compressive stress derived from the thermal expansion caused by the rapid temperature elevation of the wafer.

Detailed Description Text - DETX (10):

Also, in the embodiment described above, the electrostatic chuck electrode is divided into two portions. Alternatively, it is also possible to divide the electrostatic chuck electrode into three or more portions. FIGS. 4A and 4B are graphs showing the change with time in the chuck voltage and the change with time in the wafer temperature, covering the case where the electrostatic chuck electrode is divided into three portions. The chuck voltage ($\pm V$) is plotted

on the ordinate of the graph of FIG. 4A, with the time (seconds) for applying voltage to the chuck electrode being plotted on the abscissa. On the other hand, the wafer temperature (.degree. C.) is plotted on the ordinate of the graph of FIG. 4B, with the time (seconds) for applying voltage to the chuck electrode being plotted on the abscissa. Since the central portion of the wafer is chucked first, it is possible to prevent the wafer from being rubbed strongly on the hot plate in this case, too. As a result, it is possible to prevent the particle generation. It is also possible to prevent the compressive stress from being generated in the wafer so as to prevent the wafer from being broken. The effect of suppressing the wafer breakage can be further improved in this case, compared with the case where the electrostatic chuck electrode is divided into two portions.

Detailed Description Text - DETX (17):

Further embodiments of the present invention will now be described with reference to FIGS. 12 and 15. Specifically, FIG. 12 is a cross sectional view schematically showing the construction of a semiconductor manufacturing apparatus (sputtering apparatus) in which is arranged a hot plate 34. FIG. 13 is a graph showing the change with time in the chuck-releasing voltage in the chuck-releasing time. In the hot plate 34 according to the third embodiment of the present invention, the electrostatic chuck electrode is divided into two electrode portions, and the surface of the plate body on which the wafer is disposed is formed flat as in the first embodiment described previously. The sputtering apparatus comprises a sputter chamber 30, which is provided with a sputtering gas introducing port for introducing a sputtering gas such as an Ar gas into the sputter chamber 30. The sputter chamber 30 is also provided with a vacuum exhaust port connected to a vacuum pump (not shown) and, thus, the sputter chamber 30 can be exhausted to set up a vacuum state. Arranged within the sputter chamber 30 exhausted to set up a vacuum state are a cathode 32 holding a target 31 and the hot plate 34 positioned to face the cathode 32. A back surface monitor probe 35 for detecting the state of the back surface of a wafer 33 is arranged on the side of the stage on which the hot plate 34 is arranged. The hot plate 34 is heated to 450.degree. C. As in the embodiment shown in FIG. 1, the electrostatic chuck electrode of the hot plate 34 is divided into two portions, i.e., into the inner circumferential electrode portion and the outer circumferential electrode portion. The inner circumferential electrode portion includes a first electrode portion for applying a positive voltage and a second electrode portion for applying a negative voltage in the chucking step. Likewise, the outer circumferential electrode portion includes a first electrode portion for applying a positive voltage and a second electrode portion for applying a negative voltage in the chucking state. These electrodes are connected to a chucking power source

controller 36.

Detailed Description Text - DETX (20):

In the next step, a sputtering gas is introduced into the sputter chamber 30. When a predetermined sputtering gas pressure has been set up within the sputter chamber 30, a DC power is applied to the target 31 for a predetermined time, thereby finishing the film forming operation. Then, the discharge process is performed on the basis of the chuck-releasing parameter determined in advance based on the back surface state so as to transfer the wafer 33 out of the sputter chamber 30, thereby finishing a series of the sputter film forming process. The back surface monitor probe 35 serves to determine the electrostatic chuck parameter. It is also possible to use the back surface monitor probe 35 together with an emissivity measuring probe for calibrating the temperature of an infrared emissivity thermometer. In the third embodiment shown in FIG. 12, the back surface monitor probe 35 is arranged within the sputter chamber 30. Alternatively, it is also possible to arrange the back surface monitor probe 35 in another chamber such as a load lock chamber. A conventional hot plate may be used in place of the hot plate 32. Even in use of a conventional hot plate, by detecting the back surface state of the wafer 33 by the back surface monitor probe and controlling the parameters such as the chuck voltage, the chucking time, etc. the wafer is prevented from cracking, transfer error, etc.

Detailed Description Text - DETX (30):

In the present invention, the chucking force is applied first to the central portion of the wafer so as to achieve the temperature elevation from the central portion of the wafer. It should be noted that the chucking force applied to the outer peripheral portion of the wafer is weak in the initial stage of the heating, with the result that the wafer is thermally expanded smoothly so as to weaken the stress generated in the wafer. It follows that it is possible to prevent the wafer from being broken. Also, the rubbing between the wafer and the hot plate is weak so as to suppress the particle generation. What should also be noted is that the voltage elevation and the discharge parameter, which are determined in advance by detecting in advance the back surface state of the wafer, are selected so as to automatically adjust the chucking force and the discharge time. It follows that it is possible to prevent the breakage and the erroneous transfer of the wafer.